http://dx.doi.org/10.22161/ijeab/3.6.36 ISSN: 2456-1878

Assessing the Drivers of Vegetal Cover Dynamics in the F.C.T, Nigeria using Remote Sensing/ GIS Techniques

Dr. Rakiya A.B. , Dr. Halilu A. S. , Prof. Mohammed S. O. , Dr. Vaatyough H. M, Shagari M. S. , Yusuf M.J. , Jagila J. , Aliyu I. , Eshiet R. , Akinola O. , Nsofor C.J. , Mbaiorga G. , Abdulai H. U. , Modie S. , Oje A. T. , Hamzat I. , Adedeji T. , Ajonye E. S.

Strategic Space Application Department, National Space Research and Development Agency (NASRDA)
Corresponding author: rakiya.babamaaji@gmail.com

***Abstract*— *Vegetation in Abuja has been discovered to be on the decrease and there is a dire need for proper monitoring using remote sensing and GIS technology since it has proven to be effective when examining spatio-temporal dynamics of vegetation cover. This research was aimed at assessing the extent and intensity of development in the FCT using Geospatial Techniques as it affects vegetal cover. This was done by utilizing remotely sensed data such as Tamsat rainfall data, Landsat TM, ETM and L8 data, to examine the changes in vegetation and monitor vegetation health in the FCT using Normalized Difference Vegetation Index (NDVI) which has long been used and widely accepted as an effective means of estimating changes in vegetation cover. The study showed that vegetation cover has depleted tremendously at alarming rate of about 34.8% within the period of three (3) decades (1987-2016) in the study area. It also showed NDVI and rainfall were found to be highly correlated (r=0.72) indicating that temporal variation of NDVI is linked to precipitation.*

Keywords*— *AVHRR, NDVI, GIS, Spatio-Temporal, Remote Sensing.

I. INTRODUCTION

1.1 Background of Study

Vegetal cover is an important variable in many earth system processes [1]. It is the assemblages of plant species and the cover they provide [4]. Vegetation also represents an important natural resource for humans and other species. Monitoring and evaluation of the types and extent of vegetation is important for resource management and issues regarding land cover change [5]. Vegetal cover today is altered primarily by direct human use and any conception of global change must include the pervasive influence of human action on land surface conditions and processes. As the human population increases and more people relocate to urban areas, anthropogenic factors are having a profound effect on the urban environment, thus redefining vegetation which has introduced new challenges and research opportunities. This has resulted in an increase in social burden in the urban cities [3].

The Federal Capital Territory (FCT) is diverse and varied with respect to biophysical composition. FCT is characterized with savannah vegetation with 53% of grass land, 12.8% of woodland and 12.9% of shrub lands. FCT has witnessed tremendous developmental activities since inception. Most of these developmental activities include massive infrastructural developments like roads, dams, residential and commercial layouts, schools and hospitals as well as other physical developments. These activities tend to affect the vegetal cover and natural resources of the area especially in depleting the natural vegetal cover. These activities are mostly carried out without due consideration to conservation measures and adherence to the original master plan especially in the rural areas of the FCT and are impacting negatively on vegetal cover and natural resources. This work examined the changes in the vegetation (forest, shrubs, grassland and farmlands) of the FCT for the period of three decades (1987-2016), assessing the extent, intensity and drivers of vegetal cover dynamics using geospatial techniques and the specific project objectives include: -

- To assess the extent and dynamics of changes of vegetal cover in the FCT.
- To identify the drivers of vegetal cover change in the FCT.
- Examine the temporal pattern of vegetation condition in the six area councils of the FCT.

http://dx.doi.org/10.22161/ijeab/3.6.36 *ISSN: 2456-1878*

- To examine the relationship between NDVI and Rainfall in the study area.

II. MATERIAL & METHODS

2.1 Study Area

The study was conducted in Abuja, the Federal Capital Territory (FCT) of Nigeria. The city is in the North central region of Nigeria, between latitude and 9°03′ and 9°07′N and longitude 7°26′ and 7°39′E as shown in Fig 1. The Federal Capital Territory has a land area of 8,000 square kilometres, has two distinct seasons, the rainy season that begins around March and runs through October and the dry season, which begins from October and ends in March. The Federal Capital Territory falls within the Savannah zone vegetation of the West African sub-region and divided into three Savannah types namely; Grassy, Savannah woodland and Shrub Savannah.

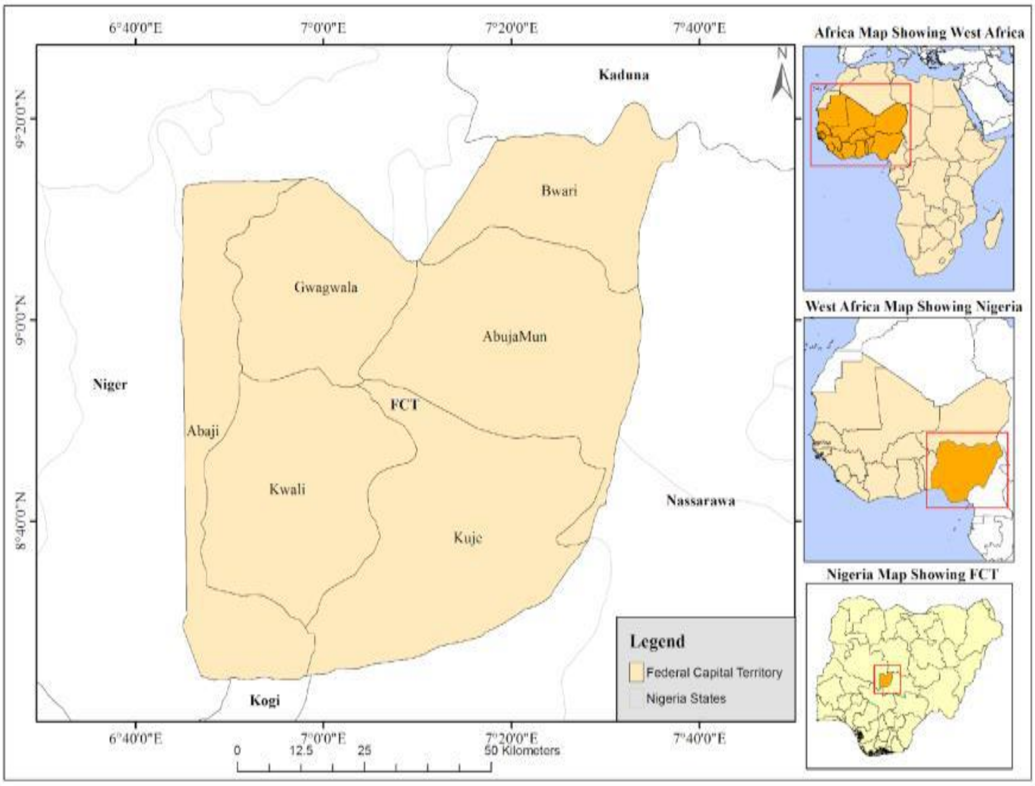

Fig. 1: Map of the study area. (Source: author's work, 2016)

2.2 Data & Methods

The primary data used for this research were acquired from field work and discussions with the local inhabitants in the study area while the secondary data were obtained from National Space Research and Development Agency (NASRDA), global land cover facility (GLCF), TAMSAT.org, and FCDA. These data included; Landsat TM, ETM and L8, and Tamsat Rainfall data at a spatial resolution of 22m, 30m, 2.5m, 1km and 4km respectively.

The methods employed in this research are broadly classified into Pre-Processing of the Satellite Imagery, Field Work and data conversion, Image classification and analysis, and Post classification. Maps were prepared from the images overlaid with settlements and road network for field guide. The methodology flowchart employed for the purpose of this research is shown in Fig. 2 below.

http://dx.doi.org/10.22161/ijeab/3.6.36 ISSN: 2456-1878

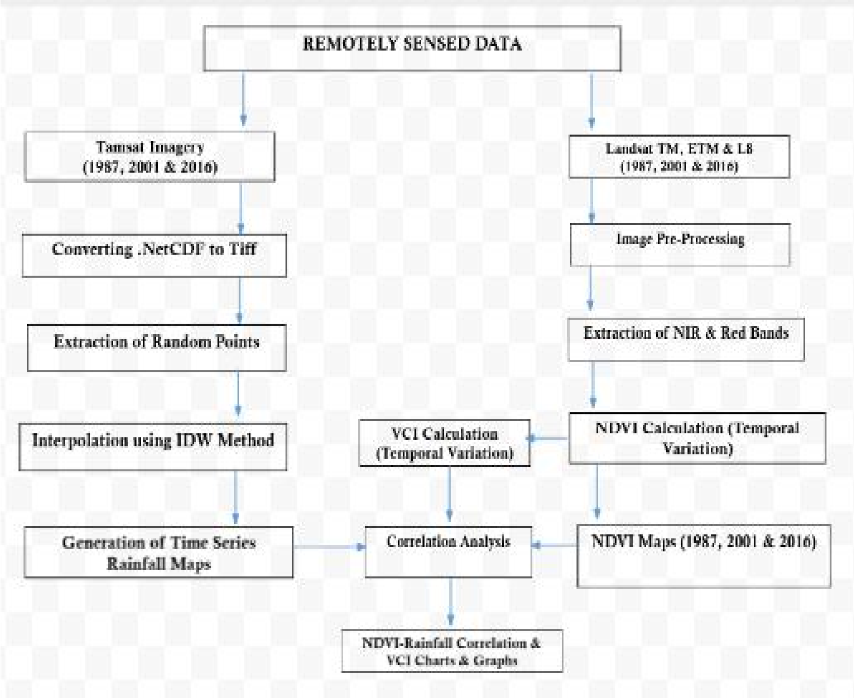

Fig. 2: Flowchart diagram illustrating methodology used for the research

NDVI, schemed in fig. 3 below is universally defined as:

NDVI=NIR-Red / NIR+RED

(Where NIR is the Near Infra-red band and Red is the red band in the electromagnetic spectrum) [2] and Rainfall Data Extraction is the most commonly used method for assessing vegetal cover and was adopted for this study. Theoretically, NDVI threshold value ranges between -1 to +1.

The study area Vegetation Condition Index was then computed using the following expression:

VCI=100*NDVI-NDVImin / (NDVImax-NDVImin)

Where NDVI, NDVImax and NDVImin are the smoothed maximum NDVI, multi-year maximum NDVI and multi-year minimum NDVI, respectively, for each grid cell.

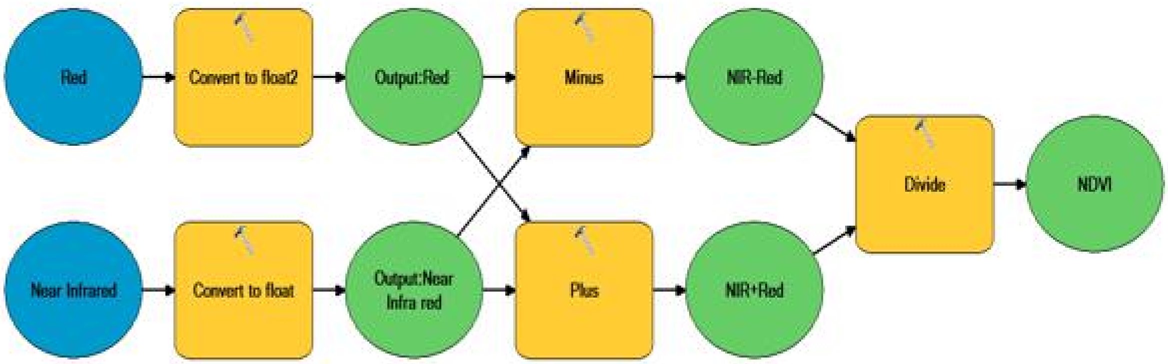

Fig. 3: Showing the Schematics of NDVI

Average rainfall data from Tamsat of the study area for over thirty-two a year period from 1981-2016 for each year was computed by using following expression:

Average RAINx=JANRAIN+ FEBRAIN+ MARRAIN+… DECRAIN12

Where, RAINx is rainfall for x year and JANRAIN, FEBRAIN………… DECRAIN stands for RAIN of particular months in that year. The locations of the rainfall stations were plotted and then interpolated using the Inverse Distance Weighting (IDW) technique in ARCGIS 10. And finally, correlation and regression

http://dx.doi.org/10.22161/ijeab/3.6.36 ISSN: 2456-1878

analyses were carried out to observe the relationship between rainfall and NDVI.

III. RESULTS AND DISCUSSIONS

3.1 Change Detection Analysis of Normalised Differential Vegetation Index (NDVI)

Normalised Differential Vegetation Index (NDVI) shows the healthiness index of the vegetal cover measured between -1 to +1. Values between -1 to 0 indicate no vegetation; 0.1-0.3 shows poor vegetation health while 0.3 to 1.0 show very good health status of vegetation.

The results in Table 1 below showed that in year 1986, Areas with no vegetal cover is about 1,481.73 km2 (20.53%) while the areas with poor vegetation health conditions covers 4,014.14km2 (52.62%) and the good health vegetation has a spatial extent of 1,720.34 km2 which is about 23.84% of the total landmass. The areas with good health condition are the Kuje, AMAC and Bwari area councils. Areas with good vegetation health condition as of year 2001, had reduced to 1,402.29 km2 (19.43%) with the Bwari and AMAC vegetation losing its vegetation healthiness most (Figures 4,5,6). Vegetation reduced by about 50% which is 2208.06 km2 affecting all the Area councils with more concentrations at the Abuja municipal. By 2016, areas with good vegetation health decreased drastically to about 853.08km2 (11.82%) while the poor Health condition covers about 2559.24km2 (35.46%) and areas with no vegetation continued to increase to about 3803.89km2 (52.71%) which is due to settlement growth and other human activities most especially in AMAC where the highest vegetation loss is drastic in the study area.

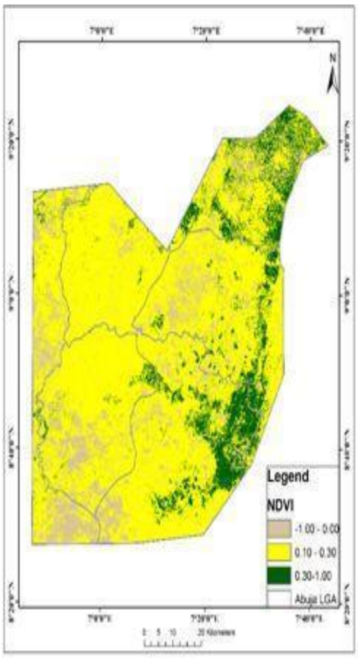

Fig.4: NDVI (1986)

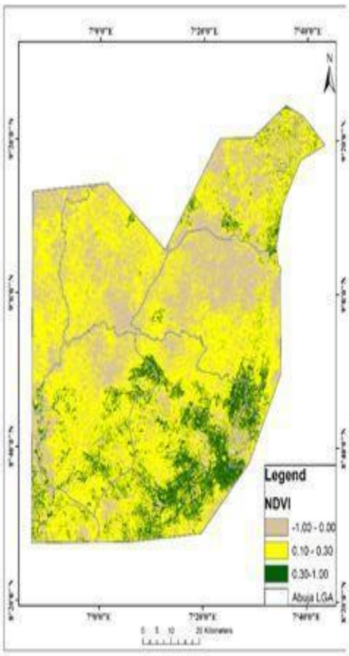

Fig 5:NDVI(2001)

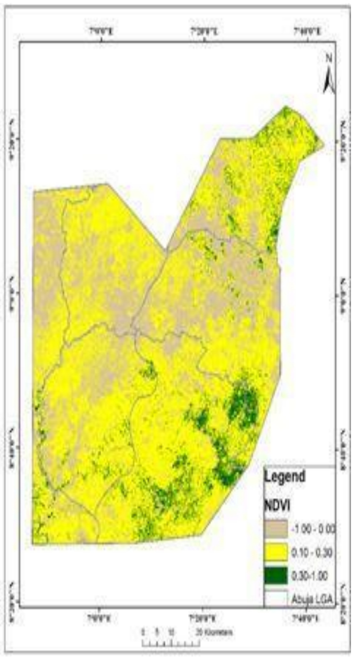

Fig 6:NDVI (2016)

Table.1: Showing Areas of NDVI in Kilometer Square and Percentage

NDVI Categories	Year 1986 Area km ^{2}	%	Year 2001 Area km ^{2}	%	Year 2016 Area km^2	%
Non Vegetation	1,481.73	20.53	2,208.06	30.59	3,803.89	52.71
Poor Vegetation Health	4,014.14	52.62	3,605.88	49.96	2,559.24	35.46
Good Vegetation Health	1,720.34	23.84	1,402.29	19.43	853.08	11.82

http://dx.doi.org/10.22161/ijeab/3.6.36 *ISSN: 2456-1878*

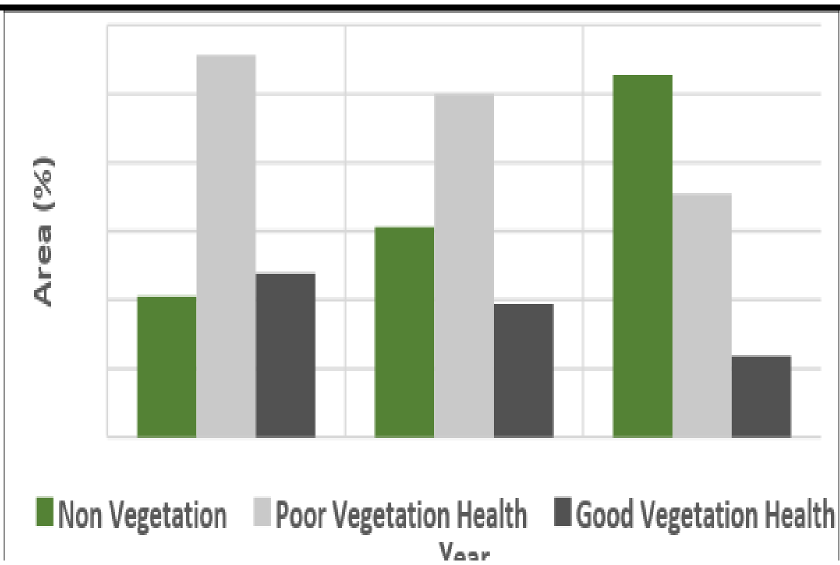

Fig. 7: Bar chart showing Areas of NDVI in % and Kilometre Square

3.2 Examining the drivers of vegetal cover change and the temporal pattern of vegetation condition.

The drivers of vegetal cover change is basically urbanization from the increase in settlements as noted from the mean NDVI results in fig. 8 and table 2 below. The mean NDVI across the LGA showed that Abuja area council has the lowest vegetation health in the area council which is attributed to increase in settlement while Kwali Area council has the highest vegetation health. From the result, two area councils which is Kuje and Kwali Area councils have good vegetation health while the remaining four area councils have Poor vegetation health condition.

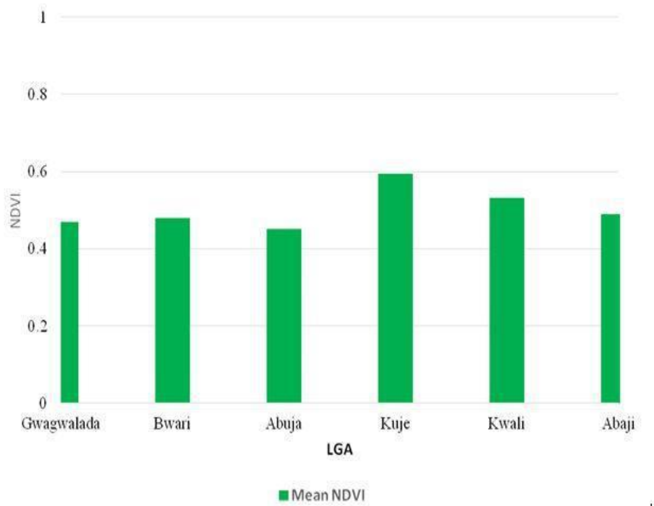

Fig. 8: Mean NDVI for the Six Area Councils

Table 2: Showing the Mean NDVI value across the area councils

Area Council	NDVI value
Gwagwalada	0.47
Bwari	0.48
Abuja	0.45
Kuje	0.5
Kwali	0.53
Abaji	0.49

http://dx.doi.org/10.22161/ijeab/3.6.36 ISSN: 2456-1878

The result in Fig. 9 below shows the temporal pattern of vegetation condition index at the FCT. Figure 11 showed that year 1995 had very high drought severity while Years 1987, 1990, 1993 and 1999 had no occurrence of vegetative drought. Other years during the period of observation are experience low severity of drought during the period of study.

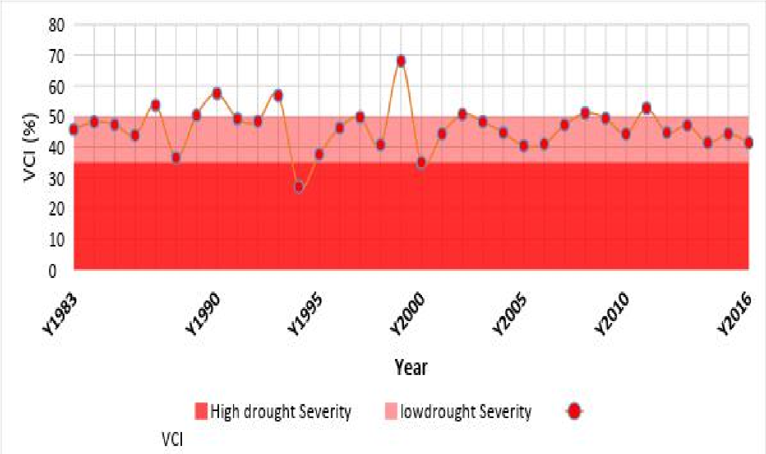

Fig. 9: Temporal Variation of Vegetation Condition Index (year 1981-2016)

3.3 Examining the relationship between NDVI and Rainfall

Considering the average seasonal rainfall and NDVI patterns for FCT Abuja for the period 1981-2016, as depicted in fig. 10 and fig. 11 below, there exist a strong correlation between NDVI and rainfall. The rainfall is characterized by low amount in December, January and February which is the Harmattan period having rainfall less than 100mm which corresponds to low NDVI values of about 0.3. The rainfall continued to increase till May having about 150mm while NDVI continued to increase till June (0.55) showing improved health condition in the study area. NDVI-Rainfall correlation was found to be highly influenced by mean rainfall it is therefore concluded that temporal Variation of NDVI is linked to precipitation.

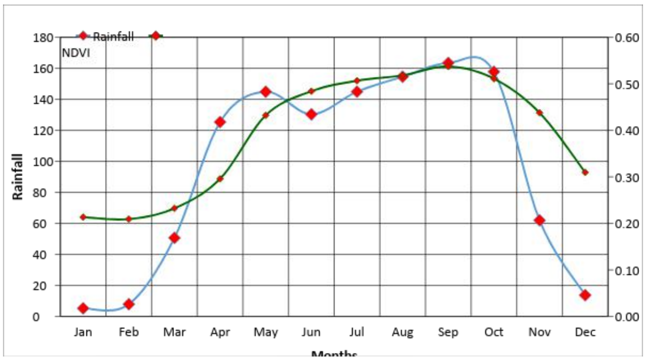

Fig.10: Monthly Variation of NDVI and Rainfall in Abuja FCT

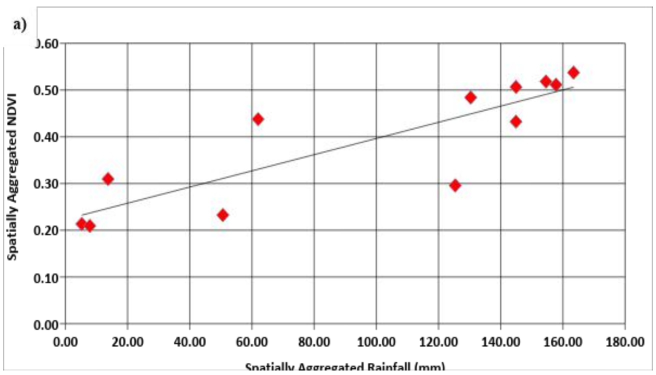

Fig. 11: Relationship between Spatial Aggregated NDVI and Rainfall

http://dx.doi.org/10.22161/ijeab/3.6.36 ISSN: 2456-1878

3.4 Discussions

This study employed the use geospatial techniques in assessing the vegetal cover in the FCT for sustainable development. The objectives of the research included to identify the drivers of vegetal cover change in the FCT, to assess the extent and dynamics of changes of vegetal cover in the FCT, to examine the relationship between NDVI and Rainfall and to examine the temporal pattern of vegetation condition in the six area councils of the FCT for necessary intervention and sensitization on vegetal cover preservation for sustainable development.

The results of the Normalised Differential Vegetation Index (NDVI) indicate changes in terms of the quality of the vegetal cover in the FCT for the epoch of the study. The results showed an increase in the non-vegetation features (such as water, rocks and bareland) from 20.5 % in 1987 to 30.6% in 2001 and 52.7% in 2016. The poor health vegetation reduced dramatically in 1987, 2001 and 2016 as 52.6%, 49. 96% and 35.46% respectively. The NDVI values for the poor heath vegetation ranges between 0.1 to 3. The good health vegetation ranges between 0.4 to 1. It reduces from 23.8% in 1987 to 19.4% in 2001 and to 11.8% in 2016.

The NDVI of the six area councils were computed and the result shows a spatial variation in terms of healthiness index of the vegetation. Based on the healthiness quality index, Kwali area councils recorded high NDVI value of 0.53 followed by Kuje area councils with 0.5. Abaji, Bwari and Gwagwalada area councils has 0.49, 0.48 and 0.47 respectively. Amac has the least value of NDVI with 0.45. Based on the statistics above, Amac is the most affected area councils in the FCT in terms the healthiness index. This can be attributed to the human induced activities such as expansion of settlement and intensification of agriculture aimed at meeting the food security of the teaming population. The results of the NDVI of the six area councils conformed with the results of hotspot analysis which showed Amac and Gwagalada as the most affected area councils in terms of human induced activities in the FCT. Correlation analysis were carried out to determine the relationship between rainfall and NDVI. The results indicate positive relationship (r=0.729). This implied that rainfall exert significant impact in terms of the healthiness and quality of vegetal cover in the study area.

IV. SUMMARY & CONCLUSION

4.1 Summary of Major Findings

In summary, the study used geospatial techniques to assess the changes in the natural land cover in the FCT for sustainable development. The research also identified the major driver of land cover change, it also identifies the hotspot areas for necessary interventions.

Based on the research undertaken, the following were major findings:

- The results of the NDVI analysis carried out in the study area showed that Amac and Gwagwalada area recorded the least values of 0.45 and 0.47 respectively.
- Vegetal cover has depleted tremendously at an alarming rate of about 34.8% within the period of three (3) decades (1987-2016) in the study area.
- The major contributors or drivers of vegetal change were urbanization or increase in settlements bare surface and rock outcrops as indicated in the change detection analysis carried out using land change modeler.
- The result of the correlation analysis portrays a positive relationship between rainfall and vegetation. This implied that rainfall is an active driver of vegetal cover change in the study area.

4.2 Conclusion

Geospatial technology has proven to be the most effective tools of measuring impact of human activities in the ecosystem as it provides models and modules for analyzing, inventorying and quantifying the rate of vegetal change in the FCT. From the relationship between rainfall and NDVI, it was concluded from the study that temporal variation of NDVI are closely linked with precipitation and there is a strong linear relationship between NDVI and precipitation for Abuja, FCT. A strong relationship exists between annual rainfall and season-integrated NDVI for all of FCDA in Abuja (r^2=0.7). This research concluded with a call for action to develop mitigation strategies that include comprehensive vegetation monitoring and early warning systems using geospatial technology, appropriate impact assessment methods. The role and importance of vegetation in cities need much more attention. Vegetation is an inexpensive way to have a significant impact in the lives of urban residents, as vegetation not only modifies the climate and creates areas of cool; it absorbs pollution and particles as well as adding to the beauty of cities. Policies could be considered for planting vegetation, for instance via new guidelines for urban landscape design and construction.

ACKNOWLEDGEMENTS

The National Space Research & Development Agency (NASRDA) greatly facilitated this research and contributions of associate scholars from the National Space Research & Development Agency, Nigeria are appreciated and acknowledged.

http://dx.doi.org/10.22161/ijeab/3.6.36 *ISSN: 2456-1878*

REFERENCES

[1] Hansen, M. C., Defries, R. S., Townsend, R. G., & Shlber, R. (2000). Global Land Cover Classification at 1km spatial resolution using classificatiion tree approach. *International Journal of remote Sensing*, 1331-1364.

[2] Lillesand, T.M. and Kiefer, R.W. (1994) Remote Sensing and Image Interpretation. 3rd Edition, John Wiley and Sons, Inc., Hoboken, 750.

[3] Rudis, Victor A.; Gramann, James H.; Ruddell, Edward J.; Westphal, Joanne M (1988) Forest Inventory and Management-Based Visual Preference Models of Southern Pine Stands Volume 34, Number 4, 1 December 1988, pp. 846-863(18).

[4] Sellers, P. J., Dickson, R. E., Randall, D. A., Betts, A. K., Hall, F. G., Mooney, H. A., Henderson-Sellers, A. (1997). Modelling the exchange of energy, water and carbon between continents and the atmosphere. *Science*, 502-509.

[5] Townshend, J. G. (1992). Improved Global Data for Land Applications: A proposal for a New High Resolution Data Set. *International Geosphere-Bioshpere program*, (p. 20). Stockholm.